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IS 5440 (1969): Optical Flats [PGD 25: Engineering Metrology]

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Indian Standard

SPECIFICATION FOR OPTICAL FLATS

(Incorporating Amendment No 1)

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Indian Standard

SPECIFICATION FOR OPTICAL FLATS

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Indian Standard

SPECIFICATION FOR OPTICAL FLATS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 24 October 1969, after the draft finalized by the Engineering Metrology Sectional Committee had been approved by the Mechanical Engineering Division Council

0.2 Optical flats are used for testing the flatness of precision measuring surfaces of flats, slip gauges, measuring tables, etc Plane parallel optical flats are used for testing measuring surfaces of micrometers, measuring anvils, and similar length measuring devices for flatness and parallelism.

0.3 In preparing this standard, considerable assistance has been derived from the U S Federal Specification GG-0-635 1960 'Optical flats' issued by USA Federal Supply Service

0.4 This edition 1.1 incorporates Amendment No 1 (October 1996). Side bar indicates modification of the text as the result of incorporation of the amendment

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This specification covers optical flats made of quartz and glass for use in the standard and inspection laboratories for the determination of flatness and parallelism of precision gauges by examination of interference patterns obtained with a monochromatic light.

2. TYPES AND GRADES OF FLATS

2.1 There shall be two types of flats.

a) Type A — single surface flat, and
b) Type B — parallel flats with both surfaces flat and parallel to each other.

2.2 There shall be two grades of optical flats in each type:

a) Reference Grade or Grade I, and
b) Working Grade or Grade II

---

*Rules for rounding off numerical values (*revised*)

3. MATERIAL, WORKMANSHIP AND FINISH

3.1 Material — The material of optical flats shall be fused quartz or borosilicate glass. It shall be clear and colourless and shall be free from inclusions and defects like air bubbles, internal strains and extraneous matter The coefficient of linear expansion for fused quartz shall not exceed 0 6 × 10 $^{-6}$/deg and for borosilicate 3 6 × 10 $^{-6}$/deg at about the standard temperature of 20°C.

3.2 Workmanship and Finish — The cylindrical surfaces shall be finished by grinding, the working (flat) surfaces shall be finished by lapping and polishing so as to produce straight and parallel interference fringes when viewed under a monochromatic source of light by placing the flat in contact with a reference flat surface. The edges of the flats shall be bevelled to 45° by a suitable grinding or polishing process so as not to produce any chipping at the edges

4. DIMENSIONS

4.1 The dimensions of Type A flats shall be in accordance with the values given in Table 1 The dimensions of Type B flats shall be in accordance with the values given in Table 2

4.2 The flats shall be cylindrical in form with the working surfaces flat. The working surfaces of each Type B flat shall be inclined to each other by about 5 minutes.

5. DESIGNATION

5.1 Type A flats shall be designated by their diameters and Type B flats by their thicknesses together with the number of this standard.

Examples

1) A Grade-I Type A flat of diameter 25 mm is designated by
   Optical Flat I A 25 — IS 5440
2) A Grade-II Type B flat of thickness 12 125 mm is designated by:
   Optical Flat II B 12 125 — IS 5440

6. ACCURACY

6.1 The tolerances on flatness of Type A optical flats shall be in accordance with the values given in Table 3 The tolerances on flatness, thickness and parallelism of Type B optical flats shall be as given in Table 3

6.1.1 Some of the methods generally adopted for determining the accuracy are given in Appendix A. The use of other methods is not precluded.

7. MARKING

7.1 Each flat shall be marked clearly on the cylindrical surface with the grade and type and an identifying serial number together with the manufacturer's trade-mark In the case of Type B optical flats, these shall in addition be marked with the nominal thickness.

7.2 A Grade I flat shall be identified by a black dot about 1 mm in diameter on the cylindrical surface of the flat and away from other markings. Further the working surface of a Type A optical flat shall be indicated by an arrow head on the cylindrical surface pointing towards the working surface.

7.3 The optical flats may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act, and the Rules and Regulations made thereunder Presence of this mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard, under a well-defined system of inspection, testing and quality control during production This system, which is devised and supervised by ISI and operated by the producer, has the further safeguard that the products as actually marketed are continuously checked by ISI for conformity to the standard Details of conditions, under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution

8. PACKING AND STORAGE

8.1 Each Type A optical flat shall be housed in an appropriate wooden or fibreboard container with seating lined with velvet or similar soft material for protecting the flat from hard knocks and dust during transport and storage. Type B optical flats shall be packed in sets of four or individually in wooden or fibreboard containers and when packed in sets, shall be arranged so as to be in adjacent seatings meant for the purpose and lined with velvet or similar soft materials to protect them from mechanical shocks, dust and moisture. All containers shall be lined throughout on the inside with velvet or similar material The containers when closed shall fully seal the flats and shall be provided with automatic locking arrangements.

TABLE 1 DIMENSIONS OF OPTICAL FLATS TYPE A, GRADES I AND II

(*Clause* 4 1)

All dimensions in millimetres

DIAMETER	THICKNESS *Min*
25	10
30	10
50	15
75	20
100	25
125	30
150	35

TABLE 2 DIAMENSIONS OF PLANE PARALLEL OPTICAL FLATS TYPE B, GRADES I AND II

(*Clause* 4.1)

All dimensions in millimetres

DIAMETER	THICKNESS
25.0	12.000 12.125 12.250 12.375
25.0	24.000 24.125 24.250 24.375

TABLE 3 TOLERANCE ON FLATNESS OF TYPE A OPTICAL FLATS AND ON FLATNESS, PARALLELISM AND THICKNESS OF TYPE B OPTICAL FLATS

(*Clause* 6.1)

TYPE	DIAMETER	TOLERANCES ON FLATNESS		TOLERANCES ON PARALLELISM		TOLERANCES ON THICKNESS	
	mm	Grade I µm	Grade II µm	Grade I µm	Grade II µm	Grade I µm	Grade II µm
A	Up to and including 100	0.05	0.10	—	—	—	—
A	Over 100 and up to 200	0.10	0.20	—	—	—	—
B	25	0.05	0.10	0.15	0.20	0.20	0.30

APPENDIX A

(*Clause* 6 1.1)

TESTING OF OPTICAL FLATS

A-1. FLATNESS TEST

A-1.1 The flatness of the working surface of an optical flat is tested by means of interference fringes (or bands) using monochromatic light such as the light from sodium mercury or helium discharge lamps. The incident light may either be diffused or parallel The comparison may be made with (a) reference or master flat of known flatness, and (b) the working surfaces of three separate flats of unknown flatness.

A-1.2 **Testing with the Master Flat** — The master flat is placed over the working surface of the flat under test so as to form between the two flats a wedge shaped air film. The interference fringes or bands are formed and seen under diffused monochromatic light. The arrangement of the set up is shown in Fig 1. The fringes observed will usually be straight lines parallel to each other if the flat under test has a perfectly flat surface. Any deviation of the fringes from straightness (in any direction) gives the degree of departure from flatness The exact calculations are similar to those illustrated in A-1.3

A-1.3 **Testing by Intercomparison with Two Other Flats** — For the purpose of this test, the flat under test *A* and also two other flats of

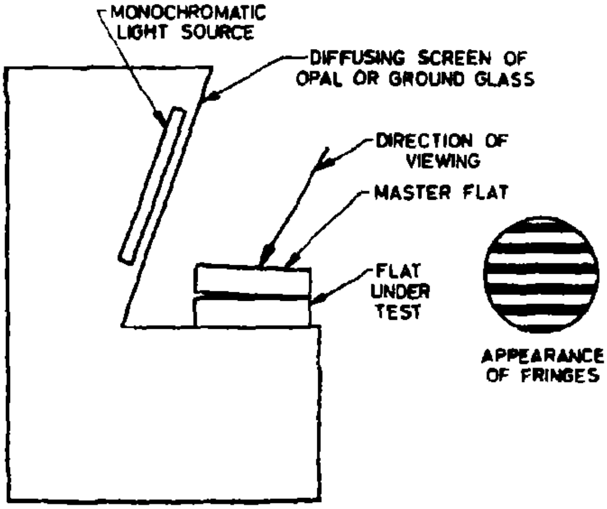

FIG. 1

unknown flatness, namely, *B* and *C*, are examined in pairs as given in Fig. 2, 3 and 4 for interference fringes. The deviations from straightness of the fringes in each case are observed under *monochromatic light on the test bench illustrated in Fig. 1* The deviations from straightness of fringes when flat *A* is placed on *B*, *B* on *C* and *C* on *A* are, for example, 1/4th fringe concave, 1/6th fringe convex, and 1/8th fringe concave respectively, as illustrated in Fig. 2, 3 and 4 These deviations are used in the calculations for determining the flatness of the flat under test The calculations are made as illustrated below

$$A + B = -0.294\,8 \times 1/4\mu = -0.073\,7 \text{ microns (1)}$$

$$B + C = +0.294\,8 \times 1/6\mu = +0.049\,1 \text{ microns (2)}$$

$$C + A = -0.294\,8 \times 1/8\mu = -0.036\,8 \text{ microns (3)}$$

(One fringe = 0.294 8 microns)

Substracting (2) from (1), we get.

$$A - C = -0.122\,8 \text{ microns} \qquad (4)$$

Adding (3) and (4) $2A = -0.159\,6$

$A = -0.079\,8$ *concave*

Substituting the value of A in (1) and (3)

$B = +0.006\,1$ *convex*

$C = +0.043\,0$ *convex*

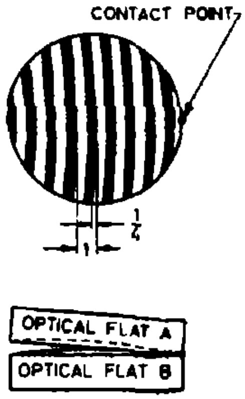

FIG 2

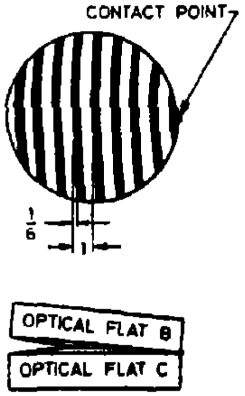

FIG 3

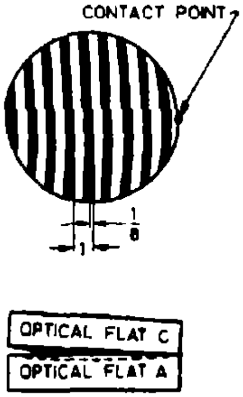

FIG. 4

A-1.4 Testing of Grade I Flats by Parallel Monochromatic Light — The arrangement is given in Fig. 5 The fringes are seen in the telescope which carries a micrometer eye-piece and in which the deviations of fringes are easily measured in terms of fringe width by means of the cross-wires. This test may also be made with either a master flat or by intercomparison of three flats of unknown flatness The method of determining the accuracy of individual flats is exactly the same as described in A-1.3

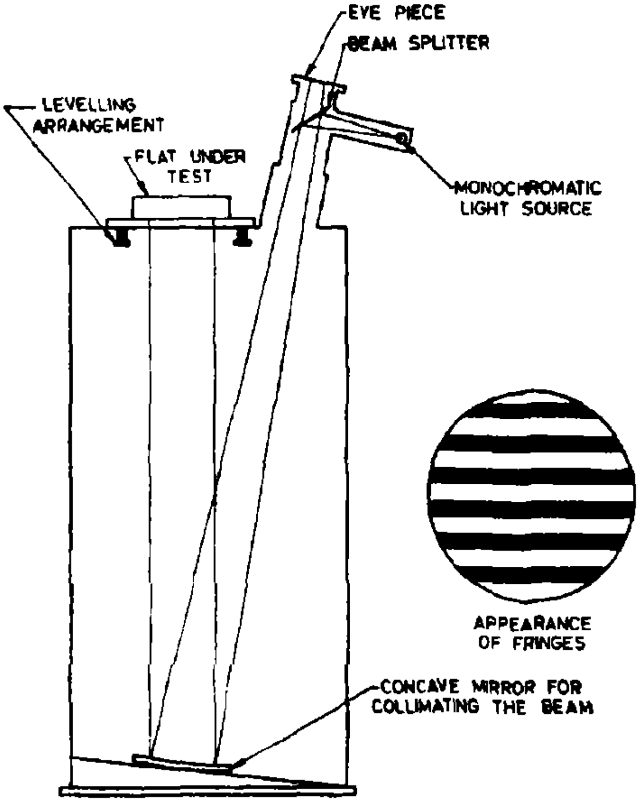

FIG 5

A-2. PARALLELISM TEST

A-2.0 The testing of parallelism of the working surfaces of type B optical flats is carried out (a) with the help of Fizeau interferometer or Hilger interferoscope, and (b) with the help of autocollimeter

A-2.1 Fizeau Interferometer Method — The arrangement of a modified Fizeau interferometer adopted for quick testing of parallel flats is illustrated in Fig. 6. Light from a mercury vapour lamp is focussed on to an opening in the eye-piece and is partly reflected by a beam splitter.

The reflected light strikes the concave mirror which collimates it and throws it on to the work holder on which the flat under test is placed and levelled in such a manner that the beam strikes the surfaces of the plate perpendicularly. After reflection from the two surfaces of the flat under test, the beam retraces its path If the flat is observed from the eye-piece, the flat seems crossed with fringes formed by interference of light reflected at the two surfaces of the flat The degree of parallelism of the two faces of the flat is then determined with the help of these fringes. The difference of the thickness of the flat at two points on the adjacent fringes is equal to $\frac{\lambda}{2} \times \frac{1}{n}$ microns where λ is the wavelength of the light used and n is the refractive index of the substance of which the flat is made This gives the optical parallelism of the two surfaces of the flat. Since the flat is made of material of uniform refractive index, this parallelism also represents the geometrical parallelism.

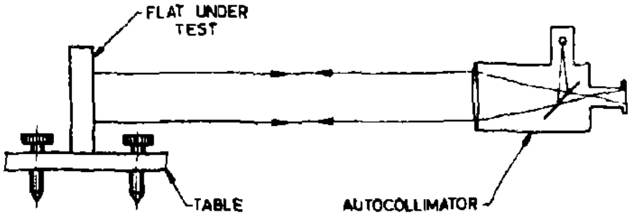

FIG 6

A-2.2 Autocollimator Method — The parallelism of type B optical flats may also be tested with the help of autocollimator using two arrangements listed in Fig 7 and 8. The flat is placed on a table with levelling screws so that its surfaces are vertical The autocollimator is used to examine the image formed by the reflection of the two surfaces as illustrated in Fig. 7

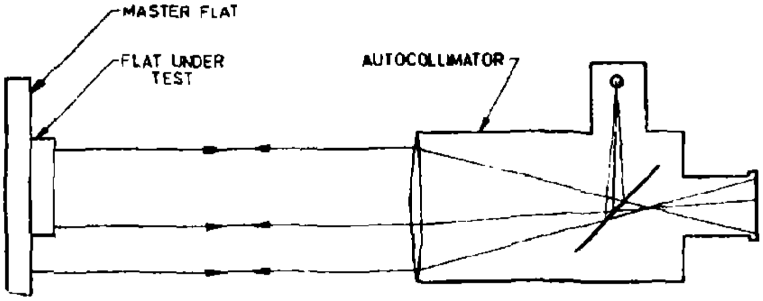

FIG. 7

Another arrangement is listed in Fig 8 In this, the flat to be tested is wrung on to a master flat and the reflection from the surface of the master flat and that from the unwrung surface of the flat are taken into consideration Wringing however entails the risk of producing scratches and extreme care should therefore be taken to avoid scratching of the surfaces.

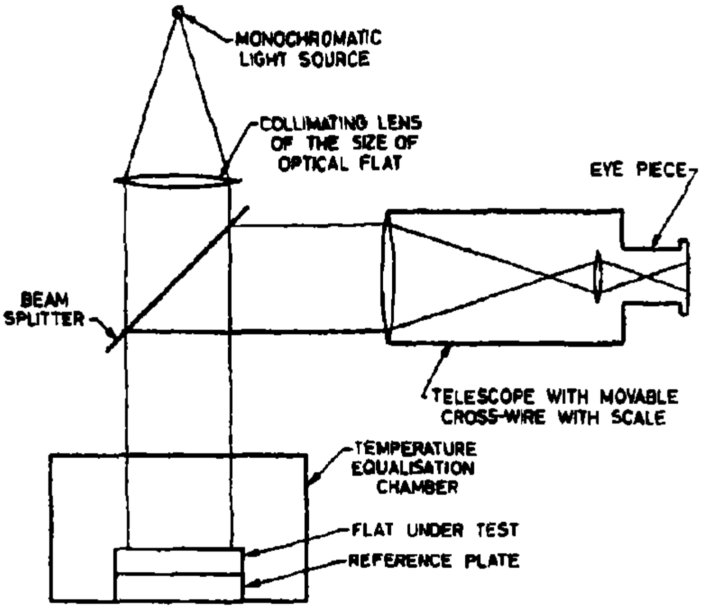
MONOCHROMATIC LIGHT SOURCE
COLLIMATING LENS OF THE SIZE OF OPTICAL FLAT
EYE PIECE
BEAM SPLITTER
TELESCOPE WITH MOVABLE CROSS-WIRE WITH SCALE
TEMPERATURE EQUALISATION CHAMBER
FLAT UNDER TEST
REFERENCE PLATE

FIG 8

INDIAN STANDARDS

ON

Engineering Metrology

IS	
919 1963	Recommendations for limits and fits for engineering (*revised*)
2092 1962	Dial gauges
2101 1962	Recommendations for limits and fits for sizes above 500 mm up to 3 150 mm
2102-1962	Recommendations for machining deviations for dimensions without specified tolerances
2103 1962	Engineer's squares
2220 1962	*Steel straightedges*
2285 1963	Cast iron surfaces plates
2554-1963	Cast iron angle plates
2709 1964	Guide for the selection of fits
2921 1964	Varnier height gauges
2949 1964	V blocks
2966 1964	Internal micrometers (including stick micrometers)
2967-1964	External micrometers
2984-1966	Slip gauges
3073 1967	Assessment of surface roughness
3179 1965	Feeler gauges (0 03 to 1 mm)
3455 1966	Tolerance for plain limit gauges
3477 1966	Snap gauges
3484-1966	Plain plug gauges
3485 1966	Plain ring gauges
3510 1966	Tool maker's flats and high precision surface plates
3512 1966	*Tool maker's straightedges*
3651 1966	Vernier calipers
4019-1967	Firm joint dividers
4052 1967	Spring calipers
4083 1967	Spring dividers
4189 1967	Firm joint inside and outside calipers
4210-1967	Strip feeler gauges for electrical purposes
4211-1967	Thread pitch gauges for ISO metric screw threads (pitch range 0 25 to 6 0 mm)
4213 1967	Vernier depth gauges
4239 1967	Bevel protractors
4241 1967	Engineers' parallels
4290-1968	Roughness comparison specimens
4349-1967	Precision rollers
4440-1967	Slip gauge accessories
4492 1968	Welded V blocks (dia range 300 to 2 000 mm)
4563 1968	*Block squares*
4583-1968	Plate snap gauges
4960-1968	Universal and elongated type V blocks
5049-1969	Gauge for wire diameters

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Amendments Issued Since Publication

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